12p

N62-15891

XEROX $ 1.60 ph

MICROFILM $ 0.80 mf

OTS PRICE

THE EXPLORATION OF SPACE

Hugh L. Dryden
Deputy Administrator
National Aeronautics and Space Administration

Cosmos Club Lecture
April 13, 1959

The surging tide of technological development has brought us to a new frontier, the frontier of space exploration and travel. We are at approximately the same stage in the development of space vehicles as the Wright Brothers were in the development of the airplane in 1904. In those days few people were interested in the fragile wood, wire, and cloth vehicles which were the forerunners of our modern jet transports and military airplanes. In fact, as a nation, we were so uninterested that the Wrights took their invention to Europe. When World War I broke out, we found that we had no airplanes of our own. We were compelled to build copies of airplanes developed by other nations.

Today the situation is different. There is widespread public interest. The competition is evident. Many now have faith in the great potentialities of space exploration to benefit mankind. I am not surprised you wished to have a discussion of this subject on your program. It is a privilege for me to tell you about the steps that are being taken to insure that the United States will occupy its proper role as a leader in space research, development, and operation for peaceful purposes.

The space age began with the launching of Sputnik I by the U.S.S.R. on October 4, 1957. The United States launched its first satellite, Explorer I, on January 31, 1958. At present ten earth satellites have been launched into orbit successfully. Three space probes penetrated to distances of 63,000 to 71,000 miles from the earth. Two space probes reached a velocity high enough to escape from the earth's gravitational field to enter orbits around the sun as man-made planets. Instrumentation on board these space vehicles provided new information about the environment of nearby space, information which increases our understanding of the earth and its atmosphere; of cosmic rays, other particles and radiations encountered by our earth in its journey through space; in fact, of

the physical universe in which we live. From the data already returned to earth from satellites and space probes containing equipment developed by James A. Van Allen, head of the physics department of the University of Iowa, have come the discovery and description of the Great Radiation Belt. This belt consists of clouds of charged particles whose impact on the satellite produces radiation of high intensity harmful to man and capable of damage to film and other photosensitive apparatus. There are in fact two radiation belts believed to be of different origins. The first has its maximum intensity at a height of about 2400 miles and is believed to be produced as a result of the impingement of cosmic rays on air molecules. The second, reaching its maximum intensity of about 10,000 miles above the earth is believed to consist of particles from the sun, whose atmosphere now appears to reach to the earth and beyond. In both cases the particles are trapped by the magnetic field of the earth and persist for a long time until as they travel back and forth in spiral paths from pole to pole they collide with air molecules releasing some of their energy to form the imposing auroral lights of the far north and south.

In addition to this fascinating discovery which I am not competent to describe in detail, the four U.S.S.R. and eleven U.S. space vehicles so far launched successfully have produced exploratory data on the distribution of matter and magnetic fields encountered in space, as well as data on solar radiation, electric field, photons, heavy nuclei, positive ions, and the physiological reactions of a dog which are as yet reported only in part by U.S.S.R. scientists. Truly an imposing record for the first year and a half of the space age.

In the early months there was wide public discussion of the organization of U.S. activities in space research, development, and operation. As an interim measure cognizance over all space programs was assigned to the Department of Defense and a study of U.S. requirements in space science and technology was undertaken by the President's Science Advisory Committee under the leadership of Dr. James R. Killian. As a result of this study the President on April 2, 1958 recommended to the Congress the formation of a civilian agency to be responsible for space activities concerned with problems of civil space flight, space science, and space technology. Military programs associated with military weapons systems and military operations were continued as the responsibility of the Department of Defense. The President further recommended that the new agency be based on the existing National

Advisory Committee for Aeronautics. The responsibilities of NACA in aeronautical research and services in support of military aeronautics and missiles programs were to be continued by the new agency and extended to military space programs. The functions of the new agency were to be considerably expanded over those of NACA to include the development and operation for research purposes of space vehicles.

After extensive hearings and consideration by the Congress the National Aeronautics and Space Act of 1958 became law on July 29, 1958, with most of the features recommended by the President. This Act expresses an important national policy with respect to activities in space, and the National Aeronautics and Space Administration was established to implement this policy. Section 102(a) reads as follows: "The Congress hereby declares that it is the policy of the United States that activities in space should be devoted to peaceful purposes for the benefit of all mankind." In Section 102(c) the Act states the objectives of the aeronautical and space activities of the United States under this policy. In paraphrased form they are:

1. The expansion of human knowledge of atmospheric and space science;

2. The improvement of aeronautical and space vehicles;

3. The development and operation of space vehicles;

4. The study of the potential benefits to be gained for mankind through space activities;

5. The preservation of the role of the United States as a leader in aeronautical and space science and technology and in application thereof to peaceful activities;

6. The interchange of information between civilian and national defense agencies;

7. Cooperation with other nations in aeronautical and space activities and in peaceful application of the results; and

8. The most effective utilization of the scientific and engineering resources of the United States in achieving these goals.

The Act, in addition to the formulation of the policy and these objectives and the establishment of NASA, created an Aeronautical and Space Council to advise the President on all significant aeronautical and space activities and on the assignment of responsibility for specific projects. A Civilian-Military Liaison Committee was also established as a channel for advice and consultation between NASA and the Department of Defense.

On August 8th the President appointed Dr. T. Keith Glennan, president-on-leave of Case Institute of Technology, as NASA's first administrator, and myself as deputy administrator. NASA began operations on October 1, 1958 at which time it absorbed the personnel and facilities of the National Advisory Committee for Aeronautics, thus ending the 43 year existence of NACA by metamorphosis. NASA thus began with nearly 8000 scientists and engineers, and technical and administrative personnel and five field laboratories: Langley Research Center at Langley Field, Va.; Ames Research Center, Moffett Field, Calif.; Lewis Research Center, Cleveland, Ohio; Wallops Island Station, Wallops Island, Va.; and the High Speed Flight Station, Edwards, Calif. To carry the new responsibilities there was added to the organizational structure space flight development in addition to aeronautical and space research and business administration. The new responsibilities for development and operation of space vehicles will be carried out largely by contract with existing industry and educational groups.

On October 1st, as a result of prior review, the President transferred to NASA from the Department of Defense the original U.S. scientific earth satellite project, Project Vanguard, with more than 160 scientists and technologists of the Naval Research Laboratory; five space probes and three satellite projects which were under the direction of the Advanced Research Projects Agency of the Department of Defense, and a number of engine development programs from the Air Force and ARPA. On December 3rd the President transferred the functions and facilities of the Jet Propulsion Laboratory, Pasadena, Calif. from the Department of the Army to NASA. At the same time NASA entered into an agreement with the Army whereby the Army Ballistic Missile Agency, Huntsville, Ala. will carry out certain NASA projects.

In the seven months of NASA's existence we have been working with a high sense of urgency on a four-fold task, (1) carrying out the on-going satellite and space probe projects transferred to the new agency; (2) planning and initiating new projects; (3) establishing long-range plans and objectives; and (4) building an organization

adequate to carry out the overall program. In our remaining discussion together I wish to outline our overall plans and objectives.

In our present appearances before Congressional committees we are asked to solemnly swear that our testimony will be the truth, the whole truth, and nothing but the truth. Dr. Homer Newell, NASA Assistant Director for Space Sciences, after taking this oath, remarked that we do not always know the truth in science and we can only try to tell the truth as we see it today. Space science and technology represents a new and unknown area of knowledge and no person can now foresee the aeronautical and space activities of the future any more than the Wrights could foresee the aeronautical activities of today in 1903. As you recall Wilbur stated that "It is not necessary to look too far into the future; we see enough already to be certain that it will be magnificent."

In line with U.S. policy as expressed in the Act, NASA has established objectives which carry out the application of space science and technology to peaceful purposes. Some of the most important relate to the applications of earth satellites to meteorology, communications, navigation, and geodetics. In some of these fields we expect that, after a period of subsidized development, the earth satellite techniques will prove less costly yet more effective than presently available methods.

The objective of NASA's meteorological satellite program is to provide the knowledge, experimental data, and component development required for an operational satellite system for weather observation, analysis, and forecasting. To accomplish this objective requires research and development on vehicles, instrumentation, data handling techniques, and satellite flights. The increased knowledge obtainable by such a system may well lead to the possibility of doing something about the weather as well as observe and experience it.

The first meteorological satellite, a very primitive one, was Vanguard II, successfully launched on February 17, 1959. It carried two infrared photocells to scan the earth's cloud cover. The instrumentation worked well and excellent electronic signals were received and recorded on the ground throughout the life of the satellite's batteries. However the satellite acquired a complex wobbling motion which has greatly complicated the reduction of the data. This satellite was the first toddling step toward our final objective. A second more sophisticated satellite is under construction and later versions are in the planning stage.

Our present concept of the system which is our objective comprises six satellites in polar orbits at altitudes of 500 to 1000 miles and three satellites in 22,000 mile equatorial orbits which travel at the same speed as the earth's surface and so remain over fixed points on the earth's surface. The satellites will be provided with instrumentation to observe cloud formations, hurricanes, tornadoes, thunderstorms, temperatures at various levels (inferred from spectral distribution of radiated energy), incoming and reflected solar radiation, etc. The data received from the satellites will be transmitted quickly (perhaps by communication satellites described below) to a central weather computing center, an enlarged version of that operated now by the U.S. Weather Bureau at Suitland, Maryland, near Washington, which is now engaged in numerical weather prediction. The operational system will be operated by the Weather Bureau, perhaps with NASA assistance in the satellite launchings.

A second NASA objective for the peaceful application of satellites is the development of the knowledge, experimental data, and component development required for a world-wide communication system capable of transmitting wide band messages including television pictures. The accomplishment of this objective requires development of vehicles, transmitters, antennas, receivers and experimental data on operating equipment. The final system might be operated by an industrial group or by government monopoly as later determined by Congressional policy. One type of system, the passive system described below, permits use of the satellite component by any nation or person providing the necessary ground equipment.

NASA's first experiments are devoted to the development of components of the passive system. It is well known that the moon may be used as a reflector of radio and radar signals if very powerful transmitters and sensitive receivers are used on the ground and the geometrical relations are correct. Satellites provide smaller moons nearer the earth which require less transmitter power and less expensive equipment. According to a study by John Pierce of the Bell Telephone Laboratories a passive satellite system may prove economically competitive with ocean cable for transatlantic communication. Television transmission would be possible over this sytem.

The first passive satellite for experiments on this method of communication is scheduled by NASA during this year. Its launching has been delayed by lack of an adequate launching vehicle. The passive satellite consists of a large inflatable sphere 100 feet in diameter which is made of aluminized mylar plastic. The sphere weighs less than 100 pounds and will be placed in a 700 to 1000 mile orbit. It can be packed for launching in a sphere only two feet in diameter. The satellite should be readily visible with about the brightness of Venus. In use a strong radio signal is reflected from the satellite in all directions, reaching the earth as a weather signal which can be received by a highly sensitive receiving antenna pointing toward the satellite.

Our present concept of a passive satellite communications system involves 10 to 20 such satellites in orbits at about 3000 mile altitude. Any nation could use the satellites as reflectors without interference with use by any other nation. Thus the launching of passive communications satellites would be an important contribution to the peaceful uses of satellites by all nations.

Time will not permit discussion of other plans and objectives for practical applications of satellites to problems of trade and commerce. I turn now briefly to the uses of satellites and space probes for the advancement of scientific knowledge of the space environment. The NASA space science program has its roots in the sounding rocket program for exploration of the upper atmosphere which began some 12 years ago with the use of captured V-2 rockets and the subsequent development of special sounding rockets. During the International Geophysical Year this program received great impetus and the U.S. fired about 200 sounding rockets and launched its first satellites and space probes.

With the cooperation of the Space Science Board of the National Academy of Sciences - National Research Council and the National Science Foundation, NASA has formulated long-range objectives in the space science program and established a definitive program for the next few years. The term "space science" has been coined to denote scientific investigations carried out in space through the use of satellites, space probes, and other space vehicles. It is not a scientific discipline in itself. Though emphasis at present is on the physical sciences, it is clear that biological science investigations will also be included.

Our program includes a number of areas and their relations one with the other. One area is that of study of the atmospheres of the earth, sun, moon, and planets with respect to chemical composition, density, motions, diffusive processes, absorption of solar radiation, etc. A second area is that of study of the ionospheres. For the earth this region is that from say 50 to a few hundred miles. The presence of the ionosphere permits reflection of radio waves for communication beyond the horizon. The state of the ionosphere is as important to long-range radio communication as is the state of the weather in the lower atmosphere to transportation and other human activities.

A third area of study has already been mentioned, the cosmic rays in interplanetary space, the Great Radiation Belt of Van Allen, and the auroral particles.

A fourth covers the fascinating subjects of magnetism, electricity, and gravity.

A fifth is that of astronomy. Satellite observations place the observer of the sky above the distortion effects of the earth's atmosphere and its absorption of a large part of the radio waves, gamma rays, ultraviolet rays, X-rays, and visible light. As one scientist remarked, satellites permit observation of the universe in full color compared to his present black and white picture.

Thus in the field of astronomy we are planning to establish and operate unmanned astronomical observatories orbiting above the absorbing atmosphere of the earth and to measure with precision the emission and absorption features of the sun, stars and nebulae in the unexplored ultraviolet, infrared, and X-ray regions of the electromagnetic spectrum.

The nearest object to us in space is the moon. NASA's plans and objectives include unmanned lunar exploration as a preliminary to ultimate manned exploration, and to investigate the surface and interior of the moon and the nearby space, including atmosphere and ionosphere if the moon exhibits such features. The space vehicles used will include lunar probes, lunar orbiters, and vehicles for rough landings, and soft landings of instruments. These vehicles are listed in accord with the estimated order of availability of the necessary vehicles and guidance systems.

The next nearest neighbors of the earth are the planets Venus and Mars. NASA's plans include exploratory probes of the space near these planets as our capabilities permit. At present our payload capacities are so small that only very limited data are obtainable even if the mission is otherwise successful. But as will be described now steps are under way to remedy this situation.

In order to accomplish the long range objectives outlined and others to be described it is essential that we develop rocket boosters and vehicles capable of putting much larger payloads into space. This is the one area where our competition is definitely ahead. NASA and the Department of Defense have planned a program extending over the next ten years to provide the vehicles required for foreseen military and non-military space missions. Time permits only a brief sketch of these developments.

At present, except for Vanguard, we are using assemblies of components and vehicles that were designed for other purposes to launch satellites and space probes. They are inefficient and expensive. Improved vehicles will soon be available such as the Discoverer satellite based on the Thor ballistic missile booster and the Hustler engine originally developed for a ground to air missile. NASA is developing a four-stage solid-propellant satellite vehicle to carry about 150 pounds into a 300 mile orbit. This vehicle, called the Scout, will be much more economical than existing vehicles and will satisfy many of the needs of our scientific program. It will be very useful in international cooperative programs.

NASA has under development the Vega, a 3-stage vehicle using a modified Convair Atlas as first stage, a second stage incorporating a modified General Electric engine which was used in the Vanguard first stage, and a JPL third stage using storable propellants. The Vega will enable us to put several tons in a 300 mile orbit and to send 1000 pounds to the neighborhood of the moon.

Later vehicles in the program are the Centaur, Saturn, and Nova. Centaur is similar to Vega except that the second stage uses high energy propellants, liquid hydrogen and liquid oxygen. The first stage of Saturn is being developed by the Army Ballistic Missile Agency as a cluster of existing rocket engines giving over one million pounds thrust. Nova will be based on a single chamber rocket of over one million pounds thrust, which is being developed by the Rocketdyne Division of North American under NASA contract.

The Atomic Energy Commission and NASA jointly are developing nuclear rockets for application to space missions as the state of development permits and on the study of nuclear power plants for use in satellites.

Finally, NASA's long-range objectives include the exploration of the solar system by man himself. Enroute to this objective are the milestones of orbital flight of man in the simplest vehicle (Project Mercury, much in the public eye last week), in advanced maneuverable vehicles, in larger satellites carrying several men, in permanent manned orbiting space laboratories, manned flight to the vicinity of the moon and back, and manned landing on the moon and return.

The objective of Project Mercury is to begin the manned exploration of space by developing the technology needed to place a man in orbit about the earth for a short time and recover him safely, and by studying man's physiological and psychological performance. By restricting the altitude to a height well below the Great Radiation Belt, no heavy shielding is required. By planning for only a few orbits before recovery, existing life support systems are adequate.

As you know from the public and technical press, the man will travel in a capsule substituted for the nose cone of an intercontinental ballistic missile. The man is supported in a reclining position on a couch for protection against the accelerations imposed by launching and by reentry into the atmosphere. The capsule is provided with equipment to supply oxygen and remove carbon-dioxide, communications and navigation equipment, altitude control jets, heat shield to protect from reentry heating, and a parachute for final landing on water. Reentry is initiated by firing a small rocket to slightly reduce the speed of the capsule in orbit.

The orbiting flight of the first Mercury Astronaut will be preceded by extensive tests and qualifications of the capsule and training of the astronaut extending over the next two years. Ballistic flights over short distances, instrumented ballistic and orbital flights, animal passenger flights, are included in this program of testing and evaluation.

A few days ago the names of the seven Mercury Astronauts who will join the project were announced. These seven men were selected from an original group of 100 military test pilots who met the general qualifications. When 80 percent of the first 69 interviewed

volunteered to proceed, the interviews were terminated. The list was then narrowed to 32 who were given extensive physical and psychological tests.

The seven astronauts will receive the most intensive course of training ever offered to a party of prospective explorers. Every conceivable characteristic of space flight, that can be simulated on the ground or in the air, will be made a part of their personal experience. Every detail of the launching, guidance, and tracking procedures will be taught them by ground crews, until they know the operation as we know the working of an office in which we have spent the better part of our professional lives. Only one can be first, but there will be several flights in the program.

All this training of the selected pilots, and all this repeated testing of the rocket and its component parts, are directed toward one end: that the first orbital flight of the Mercury vehicle shall be as nearly routine as human ingenuity and practice can make it. We are determined that the risks to the pilot will be no greater than those experienced during the first flights of a new high-performance airplane.

The Mercury project will be followed by others. In due course a permanent manned satellite will be placed in orbit around the earth, to conduct research, and possibly as a station from which to organize deeper penetrations into space. As we master the required technology we will send an expedition to the moon, and later on to Mars, to Venus, and to more distant reaches of the solar system.

May I recall to your mind the vast extent of the reaches of space as mapped by the astronomers. The most important object in our part of the universe is the sun, source of our heat, our light, and in the last analysis our food supply. In its neighborhood are nine planets which travel in orbits around the sun and accompany the sun in its motion through space. The earth is number three, at just the right distance for our delicate bodies so that we neither roast nor freeze, at a distance of 93 million miles. Our nearest neighbor, as previously mentioned, is the moon, about 240,000 miles away on the average, moving in an orbit about the earth and accompanying us on our yearly journey around the sun. The nearest planet to us is Venus, 26 million miles, the next Mars, 49 million miles away. The farthest planet, Pluto, is 3680 million miles from the sun.

To comprehend these tremendous distances let us suppose that we now had spacecraft able to travel at ten miles per second, approximately the initial velocity required to escape from the solar system or 60 times the speed of a jet transport. It would take us six hours, 40 minutes to travel the average distance to the moon, 24 days to Venus, 58 days to Mars, 108 days to the sun, 11-1/2 years to Pluto.

The nearest star is 25 million million miles away, and travel to it at 10 miles per second would require 80,000 years. It is evident that our exploration will be confined to the solar system for some time.

The greatest speed we know is that of light, 186,000 miles per second. We call the distance light travels in one year, a light year; it is nearly six million million miles. Thus the nearest star is a little over four light years away. Our sun is 26,000 light years from the center of our galaxy, the Milky Way. Such distances become almost beyond our comprehension.

Is then the travel of man to the stars a futile dream? You remember the verse:

> The world will last when gone are we
> Without a trace of thee or me
> Before we came there was no void,
> And when we're gone the same 'twill be.

I wonder. Since the invention of writing the thoughts, the knowledge, and the influence of men who lived thousands of years ago are still available. Each age builds on the shoulders of the past. Who then dares to limit the horizons of the physical universe to be ultimately explored by man? The exploration of space has begun; who knows where it will end?